TENISON WOODS, J. E.

THE TERTIARY ROCKS OF SOUTH AUSTRALIA

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ADELAIDE PHILOSOPHICAL SOCIETY.

PAPER READ MAY 2, 1865, BY THE REV. J. E. TENISON WOODS, F.G.S., F.L.S., &c.

SUBJECT—"THE TERTIARY ROCKS OF SOUTH AUSTRALIA."

No. 1.—Introduction.

It is now about 65 years since attention was first called to the Tertiary Rocks of the southern portion of the continent, and since that time very little has been done towards establishing the period to which they belong, or to fix their succession. It is known that we have in the various formations exposed on the banks of our rivers and sea beaches sections of extensive deposits; but whether they belong all to one vast province, representing one era in the world's former history, or whether they are divisible into all the various periods which the tertiary epoch includes in Europe, has never been satisfactorily explained. I propose to publish, with the assistance of the Philosophical Society, a series of papers on this subject, and I hope by placing the facts at our disposal in regular order to obtain something like a satisfactory conclusion. In order to do this, it will be necessary perhaps to give a slight sketch of what has been already done, and to notice recent investigation in tertiary formations near our continent, from which I think much valuable light may be thrown upon our investigations.

The first person to notice our Tertiary Rocks was Flinders, who, in sailing along the Great Australian Bight, saw the high cliffs of limestone which there form so remarkable an object on our shores. He imagined them to be portion of a coral reef, and described them as of a white calcareous base for two-thirds of their height, and then capped by a stratum of brown earth, in neither of which could stratification be observed, because of the great distance at which the observations were made. The lower part of the cliffs seemed to be corroded into caves and burrows, showing the stone to be of a very soft structure.

It is a matter of regret that we have no observations beyond those of Flinders of these very interesting rocks. That they are fossiliferous there can be no doubt, because Eyre was able to ascertain that fact in the course of his overland journey to King George's Sound; but no collections of the fossils have been made, and to this day we can only guess at their character.

The next person to call attention to our Tertiary Rocks was Sturt, who, in his journey down the Murray, passed by and examined the celebrated fossiliferous cliffs of that stream. He collected a number of specimens, and they are figured and described in the account of his first and second expedition (London: Boone, 1843.) With the peculiar views held by Sturt as to the origin of these beds we have just now nothing to do. The fossils he believed he had identified, were either of Middle Eocene or Miocene character, but it may be doubted whether a single one of his identifications is correct. Only two works appear to be referred to, and these seem to me to be Goldfuss's "Petrefacta Germaniæ, Iconibus Descriptionibusque Illustrata" (Dusseldorf, 1826-40); and G. P. Deshayes' "Description des Coquilles Fossiles des Environs de Paris" (Paris, 1824-37). Unaccustomed as Sturt was to the investigation of those finer shades of difference which divide species from species, it is not astonishing that he was misled by appearances; for it has been remarked by our most distinguished Australian palæontologist, Professor McCoy, that the distinctions between some of the fossils of our Miocene and those of Germany, and some of our Eocene and those of England, are of the faintest possible description. In some of his definitions he was also doubtless led astray by the imperfect character of the drawings he had to consult. As it is of consequence in the investigation upon which we are entering to point out in what respect Sturt has been in error, I shall here enumerate those species which are figured in his work, and which are wrongly determined.

In plate III, fig 1, *Eschara celleporacea* is *Cellepora Gambierensis*, Busk, not determined until many years after Sturt's publication. Fig 5. *Cellepora escharoides* is a new species which I have named *C. lunularia*, distinct from *C. nummularia*, as I shall show in a subsequent paper. Fig 6. *Retepora disticha* is a species of *Idmonea*, which is not figured sufficiently in detail to enable one to determine. Fig 7. *Retepora vibicata* is a new species *R. Gambierensis*, to be described subsequently. *Glauconome rhombifera* is *Salicornaria sinuosa*, Hassall. Fig 2. *Eschara piriformis* is as well as I can make out *Eschara Hamiltonensis*—a new species which I shall have occasion to describe. Fig 4. *Cellipora echinata* is *Pustulipora rugosa;* new species. Fig. 9. *Scutella* is, according to Dr. Duncan, identical with an urchin found in the Miocene beds of Malta. Fig. 10. *Spatangus Hoffmannii* is *Hemiptagus Forbesii* (Woods and Duncan). Sturt thought that the species was identical with one found in Westphalia, and named as above by Goldfuss. Its difference was seen by me, and I applied a name given previously to it, I believe, by some members of the Geological Survey. Desor, a French palæontologist, has made a subdivision of the *Spatangi* family, and our specimen was removed into the *Hemiptagi* division by Dr. Duncan, who, in "The Annals of Natural History for September, 1864," published a description of the fossil for the first time. The other urchin figured by Sturt is evidently a *Cidaris*. Indeterminable.

The names of five other species are given belonging either to the Middle Eocene of the Paris basin or the Lower Eocene of the London clay. They are *Corbula Gallica*, *Corbis lamellosa*, *Cytherea lævigata*, *C. obliqua*, and *Ostrea elongata;* but as none of them are figured it is impossible to say on what basis the identification rests. There is a *Corbis* in my collection which on the surface of the shell bears a good deal of resemblance to the species just named, but the hinge is very different. It came from the tertiary beds of Hamilton, which contain many specimens in common with those of the Murray. The only living specimens exist in the China seas, and might be found on the north coast of Australia. Fig. 12 is *Pecten Gambierensis*, named, however, by Sturt, *P. coarctatus*, and under this title it appears in my work. The other specimens of Sturt's plate are casts and cannot be determined, with the exception of a *Terebratula*, to be noticed subsequently.

In justice to the palæontological researches of Sturt, it should be said that in the case of the *Bryozoa*, he is not to blame for the difference between the names he gave his species and those which they have subsequently obtained. The whole of that portion of science has been recently in a shifting and unsatisfactory state, until Dr. Busk published his "Catalogue of the Polyzoa and the Monograph of the same Fossils in the Crag." As it is, we can say no more than that we are delivered from an enormous amount of most embarrassing synonyms.

From the time of Sturt we find no attempt made to describe our tertiary rocks until that of Jukes, who, in 1850, published a little book entitled "Physical Structure of Australia." It did not contain anything more than a notice of our rocks. The author seems to have visited some of the beds, but did not notice the character of the fossils any more than to state that they were tertiary.

Leichardt made some observations on the geology of Australia, but they were never published; and the few scattered notes of Strezelecki on the geology of South Australia (the south coast) contain only description of one fossil (*Terebratula compta*, Sowby), which should be a *Terebratella*.

In 1859 a notice was sent by Mr. Selwyn to the Geological Society on the classification of our tertiary rocks. Without any reference to fossils, or the evidence on which his summary rests, he merely gives the results of his observation, which are as follows:—The upper gold drift he classes as Post Pliocene, together with the raised beaches and estuary beds. The Newer Pliocene is the older gold drift, with the red marine rocks of Flemington. The Older Pliocene is the lowest of the gold drift, with the Upper Brighton marine beds and the lignite beds of the coast. The Miocene beds are those of Corio Bay, Cape Otway, Murray Basin, and Lower Brighton beds. All marine, he adds, with characteristic Miocene fossils. The Eocene beds are at Schnapper Point, Hamilton, blue clays, with selenite and characteristic Eocene fossils.

The Rev. W. B. Clarke, in a paper read before the Philosophical Society of New South Wales in November, 1861, gives the above division of the Tertiary as one in which he fully coincides; but in commenting on that portion which refers to the Miocene bed he gives an opinion which I think it better to quote. He says:—"Mr. Selwyn ranks the Murray Cliffs as Miocene also. Most of the English geologists have considered them Pliocene; but the late Professor Edward Forbes believed them to be much older; and Dr. Hochstetter thought them older still, judging from some fossils I gave him, and others which he saw in the Museum. As the genus *Spondylus* occurs among them, and that genus has twenty species which are cretaceous and only twenty tertiary, and as *Spondylus* is an Eocene genus in Europe, the Murray deposits may be partly older than Miocene. I must here mention a fact with which I have become acquainted—that within a few months wells have been opened on the Murray Flats, and that at a depth of 120 feet fish teeth, said to be *Carcharodon* and as large as those from Malta, have been found. Now, as *Carcharodon* is a cretaceous and Eocene as well as Pliocene genus, these deposits on the Murray may therefore be probably as old as has been just stated, especially as the shells occur in clay, and not, as in the Murray Cliffs, in yellow limestone." After this Mr. Clarke goes into the evidence for regarding the older gold drifts as Pliocene.

Professor McCoy, in his "Essay on the Ancient and Recent Natural History of Victoria" ("Prefatory Essays to the Victorian Exhibition Catalogue, Melbourne, 1861"), gives a chronology for our Tertiary Rocks, which differs very much from that of Mr. Clarke, and to some extent with that of Mr. Selwyn. He regards the Geelong beds as Lower Miocene, and the Schnapper Point beds as Upper Eocene. From the enumeration of the fossils, however, he would seem to include the Hamilton beds with Geelong, instead of with the Eocene of the east side of Port Phillip.

Last of all, my own work on "The Geology of South Australia" gives a much higher level to the Murray beds and those of Mount Gambier, making

them both Pliocene. Palæontological determinations are, however, carefully avoided, except in the case of the Bryozoa. The corrections in the fossils *Hemiptagus* and *Pecten* have been already alluded to; but it should be mentioned, also, that the figure of *Terebratula compta* belongs to another fossil, not *T. compta*, but probably a new species. The *Nautilus ziczac* appears to be a correct determination, and its presence in the beds at Mount Gambier, while it is also a common Upper Eocene form in the Isle of Wight, is somewhat enigmatical.

I have given above all that has been done, as far as I am aware, towards a description of the tertiary beds of South Australia, with the exception of a paper forwarded by me to the Royal Geological Society, which was embodied with my work, and need not be further alluded to here. My object now is to describe the different beds, as far as I am able, before going into detail as to their palæontological evidences.

The uppermost beds we meet with in South Australia are loose shifting calcareo-siliceous sands, entirely devoid of fossils, and sometimes highly ferruginous. I believe that they are extensively distributed throughout the whole continent; and, as they lie above all the other formations, I believe they are the most recent beds we have—marine beds, that is to say, and excepting the raised beaches and estuary beds. Under these lies a coarse granular calcareous sandstone, easily decomposed, and stretching out upon the coast into reefs of fantastic form. It is irregularly stratified, and lies in patches here and there, sometimes of considerable thickness—as, for instance, Portland Bay. It generally rests there upon an older trap rock.

Underneath this is an extremely brittle white limestone of such fine grain as to be almost like chalk. It contains abundance of fossils and layers of flint. The fossils are confined almost to *Pectenidæ*, *Echini*, and *Bryozoa*, and if any others are found they are only casts. The testa of the *Echini* are always altered into crystalline carbonate of lime, and are often broken. The casts are very white, and are formed of the finest marine mud. No fragments of the original shell can be discovered in them. Corals are never found, but sharks' teeth occasionally, and then not of recent species. The flints are full of fossils, but do not seem to be from fossil sponges. Some strata of the rock are very hard and cherty, and in these the *Pectenidæ* are more numerous; in other places the stone is soft and powdery, not even hardening upon exposure. The above formation is what I generally distinguish as the Mount Gambier limestone. It is capped at Portland Bay by a coarse shelly deposit, on which the fragments are all so much broken that species cannot be identified, excepting a few oyster-shells and some sharks' teeth, belonging to recent species. A small fragment of the same deposit is seen at Mount Gambier.

Of the Murray beds I can say no more than from the descriptions of others; but I have seen a good many fossils, and can state their differences. At the North-West Bend the shells also occur in casts, often in the form of Selenite. Sometimes a mass of *Turritellidæ* is found completely converted into selenite, and quite transparent. The formation seems to abound principally with the above fossil, as well as a large species of *Nautilus*, and a *Waldheimia* also of large size, and, though very different from the *Terebratula grandis*, of the English Pliocene, has still some points of resemblance. *Bryozoa* seem to be common, and corals occur occasionally The tops of the beds are often covered with loose oyster-shells

There can be no doubt that the Murray beds and those of Mount Gambier show remarkable points of difference, though the character of the stone and some of the fossils are similar. It has already been suggested by me that the difference is one of climate and geographical, and not more than we have a right to expect where the latitude of one place is nearly three degrees south of the other. Probably, however, there may be diversities greater than can be accounted for thus. If so, I should consider the Murray beds the more ancient of the two, for reasons which I shall give at length when treating of the chronological arrangement.

The fossil cliffs of the Murray disappear long before the mouth of the river is reached, though I believe there is no dip or any elevation. It would seem to me as if the cliffs are the remains of an extensive formation which covered equally a large superficial extent of the southern portion of the continent. We know that a very great area of our tertiary rocks have been denuded away; in fact, the loose character of the strata renders them so liable to decay that, as before remarked, we only meet with them under circumstances very favourable to their preservation. Yet the fossils do not disappear. In the Murray flats deposits of shells occur, but are generally only obtained by digging. They are decidedly on a lower horizon than the cliffs; and this fact, in a locality where there has been very little disturbance of level, is an important aid in the determination of the relative ages of the beds. The fossils found in the flats are very different from the Mount Gambier shells, but possess some forms in common with those of the cliffs and those of Geelong and Hamilton, to be mentioned subsequently. Altogether, I should consider them passage beds between the cliffs and the deposits, which I shall now refer to.

At Harrow, about 120 miles from the coast, there is a small deposit of shells in ironstone. It it on a little bank in a creek leading into the River Glenelg. The fossils are entirely confined to the surface, and are so broken and worn, so altered, in addition, by a copious infiltration of hydrated oxide of iron, that it is very difficult to make out the species. A long familiarity with the Miocene fossils of Victoria has enabled me to determine a great many of the forms, which I think belong to the Hamilton deposits now to be mentioned.

At the Muddy Creek, a small tributary of the Wannon River, about five miles south of Hamilton, there is a very extensive bed of fossiliferous clays lying under a bed of trap rock some 60 or 70 feet in thickness. The strata, no doubt, owe their preservation to the volcanic stone which covers them, which here, as indeed throughout the whole of the Wannon River, is developed in the form of Doleritic Lava. It is in consequence of an accidental fissure, down which the stream flows, that the beds are revealed; but there can be no doubt that they cover a much greater area of ground than the immediate neighbourhood of the creek, for their characteristic fossils have been brought up from the bottoms of wells sunk at a distance of eight or ten miles. The strata are sometimes loose and sandy, but generally compact and even, in places converted into a hard rock of carbonate of lime. They abound in fossils of every kind, showing an equal deep-sea bottom, on to which shells were swept from neighbouring islands. The aspect of the shells, according to Professor McCoy, denotes a warmer climate, and in fact some fossils are found amongst them which still exist, but only in a much warmer sea—such, for instance, as the large *Pectunculus laticostatus*, Lamk., which is only found now in New Zealand—not, however, in a much warmer sea—the *Flabellum Candianum*, Edw. and Haime, which is only found in the Chinese seas—a *Corbis*, *Crassatella*, and *Harpa*, all of which are now confined to the tropics. It should be mentioned, however, that a more uniform type of life is found throughout the whole of the Miocene deposits—that is to say, shells seem to have had a much wider geographical range than they are known to have now, so that the argument for a warmer temperature is not quite convincing. Again, a good many shells which are found as fossils in Europe in the Miocene strata are found still living in the Chinese or Oriental seas; so that it proves rather a migration and change of habit since the Miocene times rather than a great change of climate. Yet, in spite of all this, most geologists think that there still remains evidence of a difference of climate in the Miocene period, and the beds under consideration seem certainly to favour that idea.

It has also been pointed out that the deposit is very much like what would have accumulated round a chain of rocky islands, not only in the nature of the beds, but in the character of the fauna. Many of the species of fossils are scarcely distinguishable from forms now common in the Philippine Islands. This island character proves two things—first, that the Hamilton beds were deposited under very different circumstances from the Mount Gambier beds, which are deep-sea deposits. Were there no other facts to prove the distinctness of the two this would be sufficient, for both deposits preserve their peculiar characters, and can be traced to within six miles of each other. The second thing is, that the destruction of these islands must form one of the remarkable facts in the geological history of the Australian portion of the earth's surface.

Below these beds Professor McCoy places the Upper Eocene deposits of Schnapper Point; but I have not visited them, and cannot describe them. From the fossils in my possession I can see that they are blue clays, which preserve the most delicate markings on the shells; but of about two dozen specimens, I can only count about three which I have not found in the muddy creek beds; neither have I found any *Foraminifera* nor *Bryozoa*, though I believe the latter are to be obtained.

The difference between the Schnapper Point beds and those of Hamilton is that the former is a dark-blue clay with mica and no *Foraminifera*, and the latter a light-brown ferruginous clay, containing many particles of iron oxide, and teeming with *Foraminifera*, especially *Amphistigina vulgaris*, D'Orb., whose coin-like discs are found in every pinch of the dust. The Murray beds, again, have fewer *Foraminifera*, and the shells are more frequently casts. The Mount Gambier deposits have very few shells at all and no corals, but the beds are made up of broken *Bryozoa*.

I have already indicated the succession of these various formations as I regard them, but I must add that I do not give it as a matter which is decided. The only way to settle their position will be by the determination of their geological chronology, and this can only be done after lengthened investigation. The rule adopted towards all Tertiary Rocks is to ascertain the percentage of existing species in any given bed; and according as it is more or less than others, so it is newer or more ancient. I think we are almost sufficiently acquainted with our coast fauna to be able to enter into such an investigation, but the material wanted is a sufficiently wide examination of the fossils. Tried by such a standard, however, we are not without difficulties in the very first application of the rule. The Mount Gambier rocks do not possess a single shell or urchin which is known to exist upon our shores at present. Now, I have strong reasons for believing that the beds in question are very modern, geologically speaking; but this is certainly a fact which would militate against my view were there nothing else to support it. But, as I said, the shells, &c., are so few in number that we must depend upon the *Bryozoa* for any results we may hope to obtain. Only a very few years ago it would have been hopeless to look for any results from such a source; but now so much has been done in their classification that identifications are more easy with them than in the case of some of the mollusca. What these results are I hope to point out in the course of these papers.

The Hamilton beds being very rich in shells give us a good number which still exist, and many are found common to them and all the other beds; but this should not excite astonishment. Even the Eocene or most ancient tertiary formation contains about 10 per cent. of existing species, and as they can be traced into all the other formations upwards, of course such fossils must be common to all. I am not aware that it has as yet been decided what percentage of peculiar species constitutes a separate formation; but I think we shall find in Australia that each has a sufficient number of peculiar forms to justify a separation. The rule would seem to be that differences which cannot be accounted for by climate and geographical situation should be held to indicate a different kind of marine life, and an epoch in geology.

In accordance with these rules, I would propose the following subdivision of our Tertiary beds which contain fossils:—

Newer Pliocene.—Tertiary beds near Adelaide, Government House quarry, &c.

Older Pliocene.—Mount Gambier, Portland, &c.

Upper Miocene.—Murray Cliffs.

Lower Miocene.—Murray Flats; Victorian representatives—Geelong, Cape Otway.*

* In separating the Geelong and Cape Otway beds from those of Hamilton, I believe I am justified by the fossil remains, but in making the Schnapper Point beds Middle Eocene, I differ from Professor McCoy, who makes them Upper Eocene. My reason is this:—Mr. Selwyn makes the Hamilton beds and those of Schnapper Point of the same age, but though many fossils are common to both deposits, they are not contemporaneous. The Hamilton beds are, however, older than those of Geelong, and since Professor McCoy determines the latter to be Lower Miocene, the former must be Upper Eocene. But the Schnapper Point beds are, according to the learned Professor, a step below those of Geelong; therefore they are Middle Eocene—an

Upper Eocene (not known in South Australia). —Hamilton, Victoria.

Middle Eocene (not known in South Australia). —Schnapper Point, Port Phillip.

I have only made this subdivision provisionally, and with considerable hesitation. I am but slightly acquainted with the Adelaide tertiaries, but I think they contain a large proportion of existing species; and this is a department where the members of the Institute can make useful investigation. Careful comparison of the fossils with good collections of our coast shells is all that is required, and this can be done without any attempt at classification. For my own part I only offer the above classification as a basis upon which to work. This paper is intended as an introduction to a series in which the Mount Gambier fossils will be carefully described. It is only by making ourselves familiar with the fossil forms that we can hope to arrive at any sound conclusion as to the identity or separation of different beds which are found at great distances from each other.

In my next paper I propose giving figures and descriptions of all the *Pectenidæ* of the Mount Gambier beds.

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age which would tally with the remarkable resemblance shown between the fossils of the Point and those of Barton Cliff, Hampshire. The difference between the Professor's chronology and mine is in my not regarding the Geelong and Cape Otway beds as identical; and in justice to the other side of the question I must admit that the corals hitherto described are Miocene in character, and no characteristic Eocene form, such as *Turbinolia*, has yet been found at Hamilton, but this is also true of the Schnapper Point beds, of whose Eocene age there is no question.

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ADELAIDE PHILOSOPHICAL SOCIETY.

PAPER BY THE REV. J. E. TENISON WOODS, READ BEFORE THE MEMBERS OF THE PHILOSOPHICAL SOCIETY, MAY 2, 1865.

SUBJECT—"ON THE TERTIARY ROCKS OF SOUTH AUSTRALIA."

No. II.—THE MOUNT GAMBIER FOSSILS.

I have said already that the strata at Mount Gambier contain but few shells. The deposit was thrown down from a deep sea, and however much *that* is known to teem with life, far more indeed than any one suspected until late years, yet of mollusca, properly speaking, the numbers are very few. It will be as well to point out here the signification of this fact. That the sea which formed these rocks was a deep one we may conclude from the peculiar shells which are there found (*Terebratella, Waldheimia*, and sea urchins), as well as from the nature of the beds; but the absence of any other shells tells us plainly that not only was the sea deep, but it was very far from any land whatever. For though very few of the mollusca live at a great distance from the shore, because few can exist at a greater depth than about 100 fathoms, yet these shells are carried by the waters often to considerable distances, and to depths far greater than they would reach living. Thus it is that in deep-sea dredging shells are found in considerable number of species, which are not ever seen at any great distance from the land. Mount Gambier, therefore, and Portland Bay contain rocks which represent the bottom of a former open ocean where very little of the Australian Continent could have existed.

The small number of the entombed mollusca is at the very outset a barrier to any comparison between the shells of our coast and those of the deposits. The first shells which attract attention, both for their number and diversity, are the *Pectenidæ*. These are essentially deep-sea conchifera. Some are found at depths as small as 15 fathoms, but others range to 200 fathoms. They are especially numerous in the neighbourhood of coral reefs, but are found more or less in every locality and in every geographical situation. My impression is that the animals which lived in the shells found fossil at Mount Gambier have lived and died in the position where their remains lie entombed. Facilities for locomotion are not given to many of the mollusca; and though some *Pectens* can take surprising leaps, yet others are attached by a byssus, and in an allied genus — the *Hinnites*—by a calcareous incrustation on the lower valve. In a great many instances the valves of those found at the Mount are attached together, showing the tranquil state of the sea-bottom, and that the animal must have left his tenement in that position.

The *Pectenidæ* would include, according to the present classification, many genera which are not represented at Mount Gambier or Portland. The Pectens proper have been also subdivided into the following genera:—*Pecten*, free, regular, auriculated equivalve shell, with a transverse hinge, without teeth, but in place a perfectly triangular pit for the ligament; surface of the shell with longitudinal ribs, and often transverse scales; ears unequal—the posterior one with a sinus for the byssus. This genus has been subdivided into—

Chlamys—A sub-equivalve Pecten, with striæ in rays.

Dentipecten—Equivalve and obscurely marked; hinge teeth.

Pseudamussium—Vane-shaped, thin, smooth or delicately-striated Pectens.

Vola—Superior valve, flattened or hollowed.

Janira—Superior valve, much smaller, inferior valve curving round at the umbo to meet the hinge (all fossils and secondary).

Neithea—Hinge with teeth, and the general form leading by a transition to *Trigonia*. These are also secondary fossils.

Pleuroneitia.—Orbicular sub-equivalve, thin, gaping at each side; valves finely striated; ears nearly equal, the posterior presenting a sinus. This genus was proposed by Swainson as a subdivision in 1840, but it is not clearly distinct from the genus *Ammussium* of Klein.

Hinnites—With the lower valve adherent.

The above divisions include all the forms which we know as Pectens. Some of them only occur as secondary fossils, and therefore are not likely to fall in our way here. The other subdivisions, with the exception of *Hinnites*, I shall not adopt, because, 1st, the divisions are artificial and are not formed up on clearly-defined generic characters; 2nd, intermediate forms by which the characters of one genus insensibly approach another are constantly being discovered either living or fossil. Having premised this I now proceed to describe the Pectens found at Mount Gambier.

Genus Pecten, *Bruguières*, 1789.—Shell free, regular, inequivalve, suborbicular resting on the right valve, usually ornamented with radiating ribs; beaks approximate, eared; anterior ears most prominent; posterior side a little oblique; right valve most convex with a notch below the front ear; hinge margins straight, united by a narrow ligament; cartilage internal in a central pit; adductor impressions double, obscure; pedal impression only in the left valve or obsolete. (Woodward's Man., Moll., p. 257.)

Pecten maximus, Linné.—Two or three fragments of what I believe to be this species have been found by me at Mount Gambier. They are rather worn, and therefore the identification might not appear satisfactory to every one; but as *P. maximus* is a very variable shell, and I have compared it with some half dozen specimens in my collection, I make no doubt whatever that it is the same. *Pecten maximus* is a Pliocene fossil, but it still exists in the European seas, the fish being used as food. The occurrence of the species in Australia is singular, but I am not aware that it is found in any but the fossil state. It affords a strong proof of the Pliocene age of the beds, and perhaps a solitary instance of a species which is fossil here, and has living representatives in Europe. It is not at all uncommon to find species living in the Oriental seas which have not lived in European waters since about the Middle Tertiary times, so that, as I shall subsequently show, European Miocene fossils being found in Australian formations are no proof that the age of the beds is Miocene also; but a Pliocene and recent European species occurring as a fossil alone in Australia is curious, and offers strong ground for concluding that the strata in which it occurs are of Pliocene age.

Pecten incertus. Plate 1, fig. 1.—Shell solid, thick, globose, inequivalve, very inequilateral; ears unequal and strongly ribbed; ribs on shell about 30, bifurcating at their ends, alternating towards the edge with smaller ones all covered with granular imbrications. This shell resembles *P. asper* in some respects, but it is much more inequilateral and the imbrications more regular and square, though sometimes rising into a sort of spine. Length 1·5, breadth 1·5 of an inch. I have described the species because I believe it to be new, and because it strongly resembles a species found at Mount Gambier. The specimen, however, in my possession was not collected by me, and from its mineral appearance, and from the fact that I have never found the fossil in the Mount Gambier rocks, I very much doubt its occurrence there. It is, however, said to be common at the Murray beds and at Hamilton. The drawing represents a somewhat abnormal form.

Pecten Gambierensis, Plate 1, Fig. 2.—Shell somewhat thickened, corrugated, inequivalved, very inequilateral; ears unequal—anterior one rudimentary; posterior one large, rounded, and strongly ribbed, with a sinuation for a byssus. Shell with from five to seven broad corrugations, which, together with the intercostal spaces, are covered with small imbricated and granular closely-set ribs; granulations rounded. Lines of growth strongly marked in some specimens, making transverse ridges, from which the ribs proceed at a lower level and at a different angle, giving the fossil the appearance of deformity. Length 1·5, breadth 1·4 of an inch.

Observations.—This fossil very much resembles the last, but is distinguished from it by the ribs being more closely set and never bifurcating or presenting incostal ridges towards their termination. The granulations, also, are always rounded, approximate, and depressed, never subspinous. *P. Gambierensis* may be said to be the characteristic shell of the formation. There are few places in it where some specimens are not found; but it is especially abundant in the lower strata at Beswick's Cave, Mount Gambier, and on the walls of the caves at Mosquito Plains. It has in the disposition of the larger ribs a faint resemblance to *Pecten plica* of Linnæus.

Pecten Foulcheri. Plate 1, fig 3.—Shell thin, equivalve, inequilateral, with many fine radiating ribs and nine larger ones, on which are scattered coarse, unequal, laminated, or subspinous imbrications; length, 1·6 x 1·6 of an inch. Somewhat common at Mount Gambier, but nearly always found in a broken state.

Pecten Yahliensis. Plate 1, fig. 4.—Shell thin, equivalve, inequilateral; upper valve subconvex, lower valve much more so; upper valve covered with numerous regularly but faintly imbricated ribs; lower valve with about 30 well-marked but nearly smooth ribs; ears large and unequal, those of the lower valve sinnated with serrated fringe-like edges; upper ones ribbed and imbricated as on valve, with straight margin overlapped by lower; length 2·8, breadth 3 inches. The only perfect specimen of this beautiful species was got for me in sinking a well close to Yahl, Mount Gambier; but imperfect valves are not uncommon. The fringe-like serration of the ears give the shell a marked character, which distinguishes it from any other. It is certainly, without exception, the most beautiful fossil in the formation.

Pecten pleuronectes, Gmelin, *Pleuronectes Japonica* of some authors.—This fossil I have only found in two places, but I make no doubt that it is identical with the species now living in the North Australian seas. The shell is smooth, and on both the specimens in my possession there are most distinct traces of the rich reddish-brown colouring which is found on the upper valve of the living shell. *P. pleuronectes* is found as a fossil in the Upper Tertiary beds of the Department of Drome,

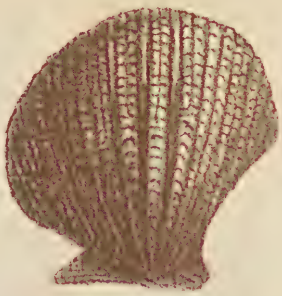
France, being one of a good many instances of fossils which lived in the Tertiary seas of Europe, but which are found living now only in Oriental seas.

General Observations.—The above forms a complete list of all the true Pectens which I have hitherto found in the Mount Gambier beds, and my search has now extended over a period of eight years. But though I have had facilities for the examination which could not fall to the lot of many, I am still of opinion that the beds have only been very slightly explored. Where the levels are so equal good sections are rare, and one has to depend entirely on caves or the sinking of wells for a knowledge of the fauna. Wells, again, do not always reach the beds; for in a large portion of the district water is found in the Post Pliocene shell beds, which, together with the sands of the Newer Pliocene, cover very large areas. From the list of *Pectens* given, I think, however, that the Older Pliocene facies is strongly marked. *Pecten maximus*, if a correct determination, is certainly not an evidence of any other than Pliocene age. I look, however, on the occurrence of *P. pleuronectes* as of more significance because of its being fossil in Europe, and still existing in our tropical seas. For if it is granted that a migration eastwards of certain species of mollusca took place from Europe at the close of the Miocene period (and this is an opinion which is held by most palæontologists), then we should expect to find Miocene forms of Europe in Pliocene beds here. This, of course, supposes a migration of the species, not a restriction to a particular district of one formerly of world-wide distribution, because in that case *P. pleuronectes* might be Miocene or Pliocene. But it is a migration, I believe, which is held, while a more uniform type of molluscan life seems to have prevailed.

My next paper will include some of the *Brachiopoda*.

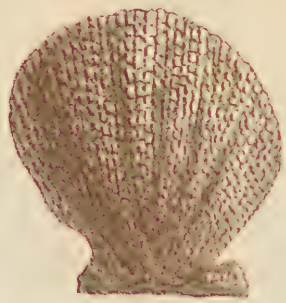
Andrews, Thomas, & Fisher, Printers, Register and Observer Offices, Grenfell Street, Adelaide.

Fig. 1.



PECTEN INCERTUS

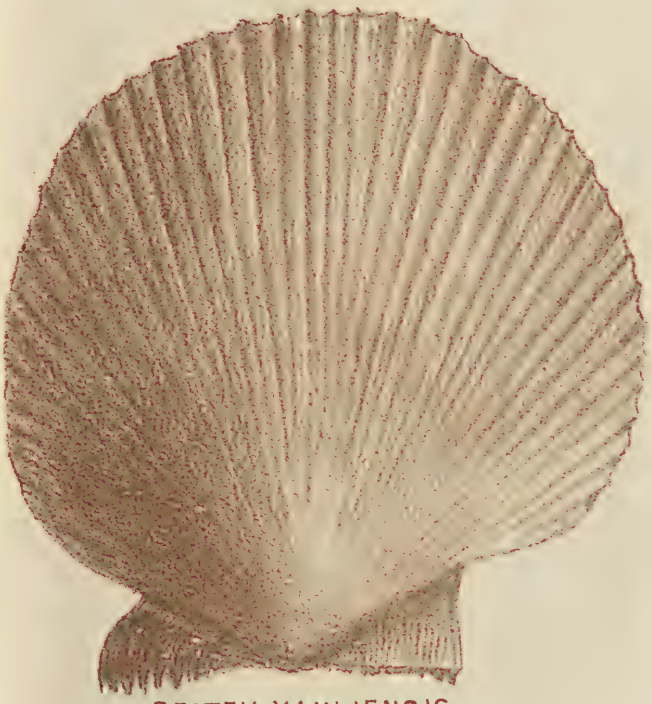
Fig. 2.



PECTEN GAMBIENSIS

Fig. 4.

B



PECTEN YAHLIENSIS
LOWER VALVE

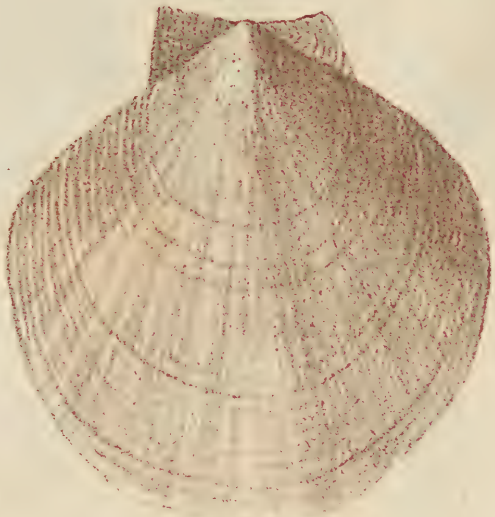
A

PECTEN YAHLIENSIS
UP. VALVE

Fig. 3

PECTEN FOULCHERI

Fig. 5



PECTEN PLEURONECTES

PENMAN & GALBRAITH, LITH.

ADELAIDE PHILOSOPHICAL SOCIETY.

PAPER READ SEPTEMBER 5TH, 1865, BY THE REV. J. E. TENISON WOODS, F.G.S. F.L.S., &c.

SUBJECT—"THE TERTIARY ROCKS OF SOUTH AUSTRALIA."

PART III.--BRACHIOPODA.

The Brachiopods are bivalve molluscs, having one shell placed on the back of the animal and the other in front. These shells are always unequal in size, but symmetrical, and the ventral or larger valve is distinguished by a perforation somewhere near its summit, through which a ligament is passed for the attachment of the animal. The valves are articulated by two curved teeth, so completely interlocked that they cannot be even opened to a moderate width without breaking the shell. As I am now engaged upon an account of fossils I shall not delay with any reference to the anatomy of the animals, which have been fully treated in the works here referred to. The best treatise on the Brachiopoda is to be found in Davidson's Monograph in the Palæontographical Society's publication for 1853. The introduction contains memoirs from Professors Owen, Carpenter, &c., and while giving the most recent observations is completely exhaustive of the subject. The best compendium is to be found in Woodward's Manual of the Mollusca. The latter is amply sufficient for all ordinary purposes of reference. It will be necessary to mention that the name Brachiopoda was proposed by Cuvier, in 1805 (Ann. du Mus., vol. 1, p. 40), from the two variously-curved and cirrated arms or labial appendages with which each animal is provided. These arms not only create currents to bring them food, but also pass fresh supplies of oxygen over the mantle, which, in the absence of any special breathing apparatus, performs the office of respiration. Owing to this one anatomical peculiarity these shells are distinguished from all others by the possession of an internal skeleton, on which the arms are supported. The various ways in which this skeleton is modified in different species has formed lately the basis on which *their* classification is established; and as to this is due the structure of the animal, we possess more knowledge of the animal than of any other class of mollusca, and it follows that the classification is more natural and more strictly in accordance with sound zoological principles. Fortunately, too, the work has been taken in hand by the most eminent palæontologists we have, and numbers amongst its labourers the names of Cuvier, Dumeril, Von Buch, D'Orbigny, De Verneuil, Gray, McCoy, and Davidson. It is to the latter, however, we owe a complete restoration of the nomenclature and classification; for, unfortunately, the number of investigators increased the number of the synonyms most terribly, and it frequently happened *not* only that one specimen received three or four different names from different naturalists, but that even specimens of the same fossil would receive three or four different names from the same observer. To show, however, how enorm[illegible] the work in this matter, even though the in[illegible]ons [illegible] only one class of a subking[illegible] a[illegible] [illegible]ned that Mr. Davidson has [illegible]ed to extend his observation to more than [illegible] series of papers in different publications, and [illegible] the splendid monographs of the Pa[illegible]al Society insufficient for the purpose [illegible] numerous and lengthy papers in t[illegible] *Geologi[illegible] Society's Journal*, the *Geologist* and [illegible] *Geol[illegible] Magazine* leave the work still incomplete.

The [illegible] are, according to the author just named, [illegible] elegant in their shapes and the most abundantly distributed of any in the Molluscan sub-kingdom. They are found in the oldest deposits at present known to contain vestiges of animal life, and have continued to exist, some in similar and many under different shapes to the existing forms. Their value to the geologist is consequently very great, because they appear in strata which contain no other fossils, and they possess in each geological period marked peculiarities of form, which enable the palæontologist to determine the age of any given deposit by their aid alone. All the various changes of form are more or less connected with the loop or internal skeleton for the brachial appendages, and it is perfectly astonishing how many varieties it has undergone. To describe the different modes in which the typical skeleton is represented would be a very lengthy task; but its magnitude may be estimated from the fact that about 40 genera and sub-genera are known, which between them number perhaps 1,000 species. But not only in *time* do the Brachiopoda enjoy a great range, but also in *climate*. They are found in tropical and polar seas, *in pools left by the retiring tide*, and at the greatest depths hitherto explored by the dredge. (Woodward, p. 209, *et seq.)* At present only 70 species are known as actually living; but many more may yet be found in deep water, because these localities are necessarily but little explored as yet, and the Brachiopoda are found more in deep water than anywhere else. Seventy species is said to be a larger number than any known to live at one time in the secondary system; but the class seems to have obtained its maximum of development in the Devonian or third great geological epoch of the primary rocks, and consequently in the very early dawn of the earth's history. There appears clearly to have been a great development, and then, after a thinning out, a gradual increase of representative species up to the present state of the earth's surface—a fact which would seem to be less easily reconciled with the Darwinian theory than any other.

Another peculiarity of the Brachiopoda is that the shells are studded with small perforations, into which short tubes of the mantle are prolonged. This enables the microscopist to determine fragments of the shells when they occur, as they frequently do in the Tertiary formation under consideration, mixed up with dust of Foraminifera and portions of Bryozoa. Dr. Carpenter states that the shell of the Brachiopoda generally contains less animal matter than other bivalves, but that *Discina* and *Lingula* consist almost entirely of a horny animal substance. There is not in these shells, nor proba*bly in any* of the *Brachiopoda*, a distinction between the *outer* and *inner layers of shell which* occurs in other *bivalves*. The loop processes are always solid and destitute of perforations. Most of the shells of the class found in the Mount Gambier formation are semi-transparent, and fragments are completely so, showing their structure well under the microscope.

Though the Brachiopoda have representatives in every formation, from the oldest to the most recent, yet the peculiarities of the modern forms are well marked and distinct. With the exception of one or two genera, they are all provided with an internal skeleton in the form of a loop. Some of the very ancient genera have representatives in even Australian seas; but as far as my knowledge extends, the Mount Gambier and Portland beds do not contain any. All the species I shall describe have a well-developed loop, and this peculiarity extends to the exclusion of all those genera, such as true Terebratulæ, which have only a very small one. I now proceed to describe the species.

Family — TEREBRATULIDÆ. Llhroyd, 1696.—
[*Ichnographia Lithophylarii Britannici.*]

Animal fixed to submarine bottoms by a muscular peduncle issuing from a perforation in the beak of the larger or ventral valve. This aperture is partly surrounded by a "deltidium" in one or two pieces; oval appendages entirely or partially supported by calcified processes which commonly assume the shape of a loop, variable in form and dimension, but always fixed to the smaller or dorsal valve; shell structure always punctated. Seven genera and five sub-genera, all based on well-defined modifications in the form and position of the calcified supports of the arms.

Genus—TEREBRATULA.

Shell oval, elongated, or transverse; extremely *smooth plaited valves*, more or less *unequally convex; margin even or waved; hinge-line curved;* beak short, terminated by a foramen variable in size and partly margined by a deltidium in one or two pieces; *loop short, confined to the posterior portion of the shell*, and not exceeding much more than a third of the length of the valve, simply attached to the hinge-plate, the two band-shaped lamellæ are soon united by a transverse lamella bent upwards in the middle. The cirrated arms are supported by the crura, and project considerably in front of the loop; *no internal septum* in the dorsal valve.

Obs.—Some palæontologists (King, Gray, &c., in opposition to *D'Orbigny*, Davidson, and others, who maintain that the difference is generic) seem disposed to consider the species with short loops are the types of the genus Terebratula, and propose to place into separate sections and sub-sections those forms in which the calcified supports before being reflected or turned back *(Waldheimia)* extend to near the margin, as wellas those in which the crura unite in the form of a band behind the mouth of the animal (Terebratulina); but these subdivisions, if of little value, are very convenient in the arrangement of the species, which may be even distinguished by external characters. Thus, in those forms with long loops the *mesial septum may easily be traced* on the external surface of the smaller or dorsal valve, while none such occurs in the short-looped species. (Davidson, loc. cit. The italics are my own.)

As yet no true species of Terebratula have been found in the Mount Gambier or Portland deposits, and this is the more singular as they are not uncommon in the Lower Miocene formation of Hamilton. One or two well-known species occur in the older Pliocene of Europe, but they do not exist in the present period. In fact, there seems to have been a gradual extinction of these forms in the Tertiary period until there has been only one species left living at present. It is not an Australian shell, and therefore we need not be surprised at the absence of these shells from our older Pliocene beds. When I say *absence*, of course I do not mean to say that there are none; but as none have been found yet, they must be rare, and will thus

prove the gradual extinction of this peculiar Brachiopod.

Sub-Genus—WALDHEIMIA. King. 1849.—*(A Monograph of English Permian Fossils*, 1849.*)*

Shell variable in shape, more or less circular, sub-quadrate, transverse, or elongated, with both valves convex, or with the dorsal concave; margin straight or waved; surface smooth or plaited; beak truncated and perforated by a circular foramen of variable dimensions, partly completed by a deltidium in one or two pieces; loop long, in general exceeding two-thirds of the length of the valve, formed of slender, shelly, riband-shaped lamellæ, simply attached by the crura to the hinge-plate, and more or less folded back on itself. The cirrated arms are partially supported by this appendage, and united throughout by a membrane exactly as in the typical species of Terebratula. The valves articulate by means of teeth situated one on each side of the deltidium, supported by plates, and fitting into sockets in the dorsal valve, in the interior of which is a prominent cardinal process and hinge-plate, with four depressions, under which originates a central mesial septum extending more or less into the interior of the shell.—[Davidson, loc. cit., p. 64.]

Waldheimia grandis. New species. Plate II., Fig. 1.—A, ventral valve; B, dorsal valve, and foramen of ventral valve; C, deltidium. Shell, smooth, very thick, elongated, convex; ventral valve, sub-carinated margin with two obscure plaits in the older specimens; beak short, obtuse, obliquely truncated, with a large circular cup-shaped thickened foramen. Loop two-thirds as long as the dorsal valve, lamellæ slender, straight, reflection unknown, septum as long as loop, gradually tapering, crura thick, semicircular. Length 2·2 inches; breadth, 1·4 inches. Mount Gambier. Rather rare.

Obs.—This is a very variable shell, but one whose thickened shell preserves it pretty perfect. I am not certain that it is properly referred to the sub genus Waldheimia, because I have only been able to dissect two specimens. In both these instances the fossil was so completely converted into selenite that I could only obtain a knowledge of the structure of the loop by grinding away the dorsal valve in small portions at a time. I could not ascertain if there was any attachment to the septum; but had there been any I think I could hardly have failed to perceive it. The lamellæ were very slender, nor was there towards their centre any thickening, such as would occur at a point of attachment. Some specimens which I have seen are strongly marked with lines of growth, while in others these are scarcely perceptible.

It is a singular confirmation to the general rule of parallel organisms in our Tertiary beds that we should find large Terebratulidæ in the older Pliocene formations. In the same geological horizon in Europe we find *Terebratula grandis*, which has many points of resemblance to the fossil under consideration. As far as external characters go, one shell might easily be mistaken for the other. They are both large smooth and massive shells wich obtuse posterior margins and large foramina; but the shell of *T. grandis* is thin and brittle, while that of W. *grandis* is very thick, and the posterior beak is much shorter in the European than in the Australian fossil, and the foramen larger. I have seen fragments of large Brachiopoda from the Murray beds, but could not state positively that they were identical with the species under consideration, though they resembled it closely.

Waldheimia Crouchii, new species. Plate II., Fig. 2.—The only specimen of this fossil which I have seen was a broken dorsal valve. It had seven large plaits upon the anterior margin, but these were only peculiar to the conditions of the animal, for the earlier lines of growth showed no such sinuations. Mere folds of this nature would not be sufficient distinctions on which to erect a species, because nearly all the larger or older Brachiopoda in this formation seem to possess them. As, however, the valve seemed to me to be flatter and the septum longer and thicker in proportion, with very small crura for the attachment of the loop, I have named it provisionally after my esteemed friend and fellow-labourer in these deposits, G. Godwin Crouch, Esq. The specimen was found at Mount Gambier. Length, 2·3 inches; breadth, 2·2 inches.

Waldheimia imbricata, new species. Plate II., Fig. 3—A, ventral valve; B, dorsal valve. Shell elongated, convex, angular in front, with a broad depressed keel on the ventral valve; margin waved; surface strongly marked with imbricated laminated lines of growth, which become sinuous and plaited as they recede from the posterior margin; beak sharply curved, with an oblique cordiform foramen; deltidium ribbed transversely; loop lamellar; curve unknown. Septum half the length of the shell. Length, 1 inch; breadth, 0·7 of an inch. Locality, Mount Gambier. Not common.

Sub-genus, TEREBRATELLA. D'Orbigny, 1847. [*"Consideration Zool. et Geol. sur les Brachiopodes, Comptes Rendus de l'Academie des Sciences*, 1847." There is a dispute as to priority, according to Mr. Davidson, between our own Professor McCoy and D'Orbigny. Mr. D. gives it in favour of the latter; but as far as I can gather I do not think that Professor McCoy referred to the same genus.]

Shell elongated or transverse, variable in shape; both valves regularly and unequally convex, or interrupted by a longitudinal depression in the dorsal valve; beak truncated by an oblique foramen of a circular or oval form, and partly margined by a deltidium in two pieces, at times disunited above the umbo; beak ridges more or less denned, and in some cases having between them and the hinge-line a flat or concave cardinal area; external surface smooth and variously punctated; loop, lamellar, reflected, but instead of being free during the whole of its course, receives two horizontal lamellæ at about the middle of the shell, which serve as supports.

Hitherto we have been dealing with a genus which has the loop free and detached from the septum. We come now to another, the peculiarities of which are as above described. It is not so extensively represented in species, but those which we do find are the commonest fo-sils of the beds. They are found in almost every foot of the stone, both at Mount Gambier and at Portland, and from this circumstance become a very good test to determine the contemporaneity of any deposits which are similar in mineral characters.

Terebratella compta. Sowerby *(Phy. Des., New South Wales, by Count Strzelecki*, p. 297). Plate II., Fig. 4.—A, dorsal valve, with deltidium; B, ventral valve; C, side view of both valves; D, interior of dorsal valve, showing reflection of loop and horizontal attachment; E, side view of dorsal septum and loop; F, horizontal lamellæ.

This species was described by Sowerby as follows:—Shell, smooth, thin, trapeziform; lateral margins sub-incurved, anterior margin small obtuse; hinge area large, with a longitudinal depressed line at either side; ventral valve triangular, rounded slightly, truncated in front with a small median sinus; dorsal valve faintly keeled; ligumental foramen terminal small and round. To this description I may add that the dorsal valve is sub-cordiform and flat, and both valves distinctly marked with concentric lines of growth. Septum round and solid, lamellæ of loop widening to the point of attachment, becoming again contracted at the reflection, and then extending into an almost complete circle with a slight projection towards the hinge.

In classifying this shell attention was drawn by Mr. Sowerby to the faint keel on the dorsal valve. This is the septum seen through the shell as a darkened translucent line. The existence of such a mark is a sufficient indication that the fossil does not belong to the true Terebratulæ.

Terebratella Tenisoni, new species. Plate II., Fig. 5.—A, ventral valve; B, dorsal valve; C, side view of both valves; D, side view of dorsal valve, showing prolongation of the septum; E, front view of dorsal valve, showing septum and muscular impressions. Fig. 6.—Same magnified.

Shell elongated, unequally convex; ventral valve, trapeziform, keeled deeply, and terminating in a notch at the the anterior margin; dorsal valve orbicular, and tapering to a point which fits into the notch on the upper valve; beak obtuse; deltidium striated, trigonal; foramen oblong. Septum thickened, curved, and produced so as to touch the ventral valve; attachments of the loop at the centre and nearer to the shell than to the edge of the septum; muscular impressions deep, hinge and crura sloping away from the septum, with a deep sinus in the centre, giving it the appearance of a cervical vertebra. Locality, Mount Gambier and Portland. A smaller species, probably only a variety, found in Hamilton. Size, variable, but adult specimens 0·7, breadth 0·4 of an inch.

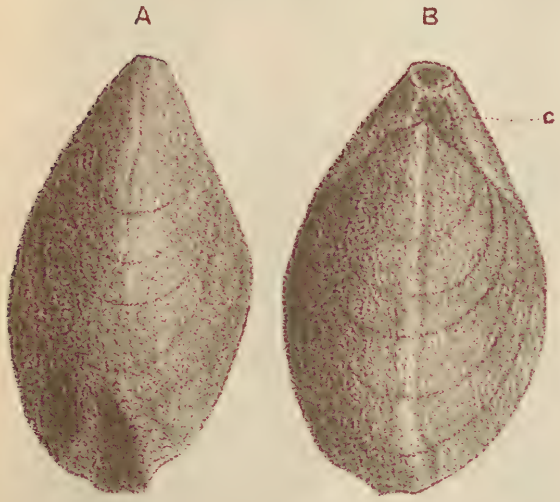
Obs—This curious species has strong points of resemblance to the *T. Eransii*, found, I believe, in New Zealand, to which it is closely allied, but whose individual characters are very distinct. In both the septum is produced so as to touch the ventral valve. The anatomy of the muscular system must have been peculiar to cause such deep impressions, and I have no doubt that when this species is more carefully examined it will be found to possess features connecting the sub-genus with other more remote members of the family.

I cannot close this paper without expressing my obligations to Mr. J. R. Y. Goldstein, of the Land and Survey Office, Portland, through whose untiring assistance I have been able to ascertain the structure of the loops of the two species just described. It would be difficult to convey the care *and nicety required* in the examination. Fossils with perfect loops are not easily found, and in dissecting them the touch of a hair will shiver the lamellæ to pieces. They are the most fragile fossils I have ever seen. It is to the pencil of the promising young geologist whose name I have just mentioned that I owe the drawing of *T. compta*, and I believe he had to dissect 20 or 30 specimens before he succeeded in getting a knowledge of the structure. The loop of *T. Tenisoni* has not yet been seen.

General Observations.—The characters of the fossils I above described are decidedly recent, and though none of the species appear to exist at the present time, yet they are intimately connected with them. Thus the development of the mesial septum in *Terebratella Tenisoni* corresponds with the same peculiarity in *T. crenulata* as well as *T. Eransii*, but in no other member of the genus is there anything exceptional about the septum. *Waldheimia grandis* is already indicated somewhat similar to *Terebratula grandis* of the European Pliocene, but the fossil has been found in the Upper Miocene as well. Nothing can be concluded as to the climate from these fossils, as they lived in a very deep sea. Here, as in Europe, there is evidence of a tropical character in the fauna of our earlier Miocene formations; but whether or not this indicates similar conditions of climate is certainly open to question.

Andrews, Thomas, & Clark, Printers, Grenfell Street, Adelaide.

FIG. 1



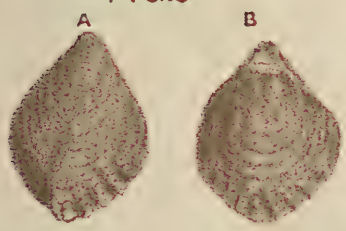
WALDHEIMIA GRANDIS

FIG. 2

WALDHEIMIA CROUCHII

FIG. 6

FIG. 3



WALDHEIMIA IMBRICATA

FIG. 4

TEREBRATELLA COMPTA

FIG. 5

TEREBRATELLA TENISONI

PENMAN & GALBRAITH

PAPER BY THE REV. J. E. TENISON WOODS, F.G.S., F.L.S., &c., READ DECEMBER 19, 1865.

SUBJECT—"THE TERTIARY ROCKS OF SOUTH AUSTRALIA."

PART IV.--FOSSIL ECHINIDÆ.

In the sub-kingdom of Radiata and Class Echinodermata there are eight orders, of which two—the *Sipunculoidea* and *Holothuridea*—are, in consequence of their soft organization and almost total absence of shell, never found in a fossil state. Two more, the *Blastoidea* and *Cystidea*, are exclusively fossil orders, which have not survived into the secondary periods of geology. The *Crinoidea* are nearly all fossil, and more common in Palæozoic and early secondary formations. Of the three remaining orders—the *Ophiuridea Asteridea*, and *Echinidea*—specimens of the two latter alone have been found in a fossil state in Australia.

The *Echinidea* are distinguished by their rounded form and the absence of any arms; their hard covering, together with their habit of living in sand, has been the means of preserving them very extensively in the geological record. As "sea urchins," or "sea eggs," they are probably familiar to every rambler on the sea-beach, where the handsome arrangement of their tubercles and the various colours of their spines make them prized objects for collectors. For particulars as to their anatomy I must refer to the various works on natural history in which they are described, especially "Carpenter's Zoology," "Echinodermata," in "Cyclopædia of Anatomy and Physiology, by Dr. Sharpey," and in a popular form in "Knight's Cyclopædia of Natural History."

In the *Echinidæ* the calcareous matter is deposited within their integument, so as to form plates of polygonal shells fitting into each other with exquisite exactness, and regularly arranged in a series with a view to the spheroidal form of the whole. These plates are perforated or covered with highly ornamented tubercles, and nothing can exceed the beauty with which these are arranged on the surface in some of the species. Between the tubercles there are generally rows of pores for the protrusion of suckers or feet; and these are the only orifices in addition to the mouth and vent and the ovarian pores on the apex whence the eggs are extruded. The classification of these interesting animals has been made to depend principally on the position of the mouth and vent; but, as Professor Forbes remarks, the work has fallen into so many hands that there has been a very needless multiplication of genera. The principal naturalists engaged on the work have been Breyn, Klein, Linnæus, Leske, Lamarck, Cuvier, Gray, Desmarest, Goldfuss, Von Buch, Desmoulins, Agassiz, E. Forbes, Desor, Defrance, D'Orbigny, Cotteau, Wright. Three species are common to the Mount Gambier Lower Pliocene rocks belonging to different genera, and none of them, so far as I am aware, exist in the present day, nor are the types now living on our coast in any way similar to them. This may be accounted for by observing that the shells found on our shores are, except in rare instances, always littoral in character, while those of the rocks are peculiar to a deep sea. No doubt urchins similar to those to be described might now be found in the deep waters of a warmer latitude, but I am inclined to think not of the same species as those found in a fossil state. We are not at present well informed as to why these singular creatures should frequent deep seas. It may be that they find there in the largest quantity Foraminifera on which to feed—a fact which is quite borne out by the fossils—or it may be that they have drifted from shallower beds, which is hardly credible, considering the way in which the remains are found. At any rate it is a singular circumstance that the first living animal which was dredged up from enormous depths in the northern seas belonged to this class, so some theory must be found which will account for geological evidence and observed facts, and at the same time conform with the known habits of these strange animals.

The common fossils of this class belong to three genera, which are thus described:—

Echinolampas—Grey (Living and Tertiary).—Test, ovoid or discoid; petals, wide, long, nearly reaching the border; vent, transverse, infra-marginal.

Echinolampas Gambierensis, new species. Plate III., Fig. 1. A, upper surface; B, lower surface; C, side view. Test, elongated, depressed, wider behind than before, upper surface convex, rounded, base convex at the margin, convex towards the peristome, ambulacral summit excentral; petaloid ambulacra increasing in width, extending completely over the dorsum; single ambulacrum narrower than the others, and very indistinct; poriferous zones narrow and continued in gradually-diverging lines to the edge of the peristome; interporiferous zones elevated; pairs of pores slightly oblique; outer series slit, and connected with the inner by distinct sulci; apicial disc small or excentral; pores two in number, large and distinct, and posterior to the madreporiform body; tubercles closely set, small, immersed, with well-defined scrobicula, those on the base being larger and better defined; vent, infra-marginal, oblique, wide, transversely oblong; peristome opposite the disc, large, excentric, and transversely oval, surrounded by fine short expansions of single rows of pores. Length, 1¾ inches; breadth, 1½ inches.

Observations.—Closely resembling *Echinolampas scutiformis* (Leske), but differing from it in its concave base and diverging poriferous zones, which are much larger in this specimen. It is allied to many characteristic Miocene forms. *E. scutiformis* is found in the upper limestone of Malta, which is, I believe, recognised as Upper Miocene—a formation which, as I have already said, is so intimately connected with the Lower Pliocene that every new exploration among the fauna of either makes their separation more difficult. The fossil figured is very common at Mount Gambier, while *Hemipatagus Forbesi*, to be afterwards mentioned, is the prevailing form elsewhere.

Hemiaster—Desor (Tertiary extinct).—Inflated urchins, with heterogeneous ambulacra, and distinctly petaloid in the dorsal portions, and often lodged in depressed spaces; mouth excentric and bilabiate; vent, terminal, petals circumscribed by a slightly undulating fasciole, which is not repeated on the base; tubercles uniform, and not distinguished by large primary ones, as in *Euptagus, Spatangus, Hemipatagus*. The above description is nearly all taken from Professor E. Forbes's monograph on the fossil Radiaria of the London clay (*Palæontog. Soc. for* 1852), and he adds that all the known species are from the Secondary or Eocene formations; but since that time specimens have been found in the Upper Miocene at least, closely allied to the one I am now about to describe.

Hemiaster Archeri. (This specimen is named after my friend Mr. W. H. Archer, Registrar-General of Victoria—a scientific man of eminent learning, whose accomplishments in natural history researches have been of much service to me in these investigations.) Plate III., Fig. 2. A, upper or dorsal surface; B, ventral ditto; C, posterior end; D, side view. Test, tumid, much elevated, truncated posteriorly, wider anteriorly; dorsal surface convex, round; ventral surface slightly convex, ambulacral summit excentral, petaloid expansions lanceolate short and inserted in deep depressions, single ambulacrum shorter and not so well defined; antero laterals slightly longer than the postero-laterals, poriferous zones oblong, pairs of pores numerous and oblique, slit, and connected by sulci, which are divided by single rows of small tubercles, an indistinct sinuous fasciole only faintly visible at the end of the postero-laterals in the adult specimens; apicial disc excentral, with three large and distinct reproductive pores; peristome opposite the disc with an indistinct fasciole or rather vacant space; mouth, bilubiate, transverse, oblong; vent, small, sub-oval, placed high upon the truncated posterior surface; tubercles scattered, uniform upon the dorsal surface, thicker set and larger on the base, sides, and round the vent, all surrounded by rings of small granules. Length, 2½ inches; breadth, $1\frac{5}{16}$ inches. Mount Gambier, rather common.

This species has many resemblances to the genus *Euptagus*, except in the presence of the primary tubercles. It may, however, be confidently referred to the genus *Hemiaster*, species of which are found at Malta in the Upper Miocene beds. Its presence there has been regarded as quite exceptional, and it is not a little remarkable that the same or similar genus has been found at Mount Gambier. This points to similar conditions of life, which are worth attention, and which connects two geological districts which are geographically very widely separated.

Hemipatagus—Desor (Tertiary).—I have now to describe one of the commonest fossils in the whole of the Lower Pliocene formations, but perhaps best represented at Mount Gambier. It has been described by Dr. Duncan, in the "Annals of Natural History" for September, 1864; but as that publication is but little known in Australia, I reproduce to the Society the diagnosis, with my own figures.

Hemipatagus Forbesi.—Woods and Duncan. Synonyms—*Spatangus Forbesi.*—Woods (*Geol. Obs., p* 75). *Spatangus Hoffmanni.*—Sturt (*Two Expeditions*, &c. *Lond.*, 1833. Vol. ii, pl. 3). Plate III., Fig. 3. A, dorsal surface; B, ventral surface; C, posterior view; D, lateral view. "This common Echinoderm," says Dr. D., loc. cit., "has been confounded both with the *Hemipatagus Hoffmanni*, Goldfuss, of Bünde, and with the *Hemipatagus Grignonensis*, Agassiz, whose synonym, *Spatangus Ormalii*, Galeotti, will be recognised as denoting a form described by E. Forbes, in the Belgian Eocene. The Rev. J. Tenison Woods has called it *Spatangus Forbesi*, but I cannot find any description of it, although it is figured (*p.* 75, *S. Australia*, Woods). The species

s clearly not *H. Hoffmanni*, and Sturt's mistake was corrected by Mr. Woods. Mr. Woods having figured the species, I append his name with my own."

I must here note that Dr. Duncan inadvertently gives me credit for a discovery which does not belong to me. Sturt's mistake was corrected by Professor McCoy as palæontologist to the Victorian Geological Survey. The learned Professor did not publish any diagnosis, and I really forget now how his determination reached me. Dr. Duncan's diagnosis is as follows:—Test, depressed, rather cordiform, nearly as broad as long, rounded and sulcated in front, rather angular laterally and truncated posteriorly. It is highest posteriorly where it is roof-shaped, and it slopes gradually anteriorly. The ambulacral summit is nearly central. Inferiorly the test is slightly concave and irregular, the plastron is smoother than the rest; the peristome is transverse, semilunar, and there is a prominent posterior lip. The anterior sulca is broad, shallow, and rounded. The ambulacral areas are lanceolate, the anterior being wide apart. The poriferous zones are sunken and broad, are slightly raised, and are faintly tuberculated. There are four generative pores, the anterior pair being closer than the posterior. There are no larger tubercles in the posterior inter-ambulacral spaces. The very small tubercles of the posterior space are very crowded. The larger tubercles which are seen inferiorly are also nearly cylindrical, perforate but not crenulate; the scrobicula is deep, and the tubercles are often in contact with one part of the scrobicular circle. Height of specimen, half-inch; length, one inch; locality, the Murray, Mount Gambier, South Australia. In the collection of the Geological Society. The species is closely allied to *H. Hoffmanni*, Goldf.; but it has not crenulate tubercles, which have a tendency to touch the scrobicular circle. It is easily distinguished from the Javan tertiary species and from the *H. Grignonensis*. It appears to be a common fossil in the South Australian tertiaries. The genus is separated from *Spatangus* by Desor on account of the defective fascioles, and of the absence of large tubercles on the posterior inter-ambulacral area. The European species are found in Eocene and Miocene strata; the nearest alliance of the new form is from Malta and Bünde. The species from the Java tertiaries are not closely allied to the Australian. In a note Dr. D. adds, "Since the completion of this paper I have received Karl A. Littel's '*Fossile Molusken und Echinodermen aus Neu Seeland.*' The *Hemipatagus tuberculatus* therein described, and decided to be specifically distinct from *H. Forbesi*, is very closely allied."

General Observations.—The connection seen in these fossils between the Malta upper tertiaries and those of our continent has been already pointed out. It certainly is very singular that two remote formations should possess in common new and unusual features which connect them in an exceptional manner with much older deposits by characteristic forms not possessed by intermediate formations. I do not know whether this peculiarity reigns out of the Echinoderms, but at any rate it does not extend to these fossils, which are almost neighbouring in Europe, nor to the same in Java, which are as near to us. It may be that the Java beds are older, and they are, I think, admitted to be Miocene. The presumption would be somewhat strong that the Mount Gambier and the Malta beds are of the same period, but differences of climate and geography may account for the successive nature of such formations without forcing the hypothesis derived from mere similarity of fossils. At any rate, the evidence from the Echinoderms make it decisive that our Mount Gambier rocks are certainly not older than the Upper Miocene at the very utmost. The reappearance of such a genus as *Hemiaster* here and at Malta is paralleled in the Mollusca by the occurrence of *Nautilus ziczac*. I shall take another opportunity of pointing out how all this evidence goes to show a greater uniformity in molluscan life in the earlier geological periods than exists at the present day.

Note.—The authors for the three genera above quoted may be consulted as follows:—

"Abhandhurgen zur Naturgeschichte, &c., von Nath. Gfrd. Leske, Leipzig, 1779."

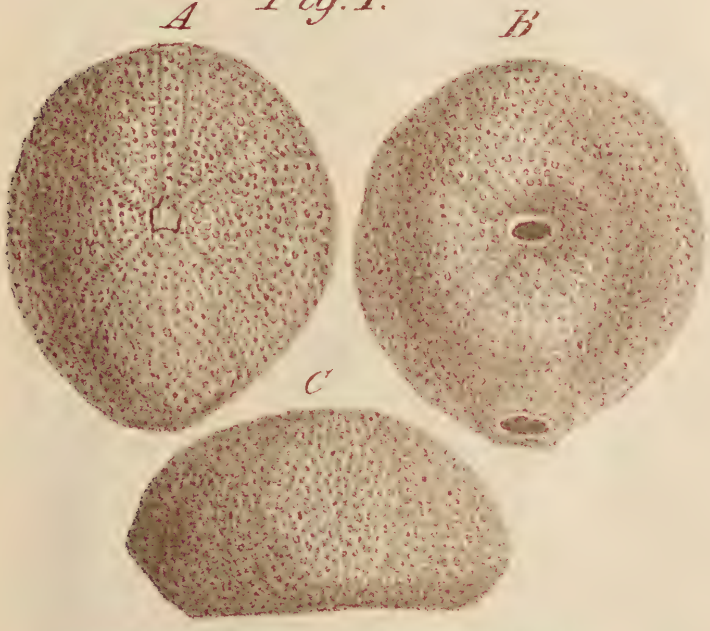
"Synopsis des Echinides Fossiles, par Desor, 6, Livraisons, Paris, 1857."

"An Arrangement of the Families of Echinidæ," in Proceed. Zool. Soc. Lon., xxiii., 1855, p. 35.

Lamarck describes many of the Echinidæ of our coast. The common sea egg is *Echinus ovum*. See Lamarck, 1st ed., vol. 3, p. 48, for that and some other species.

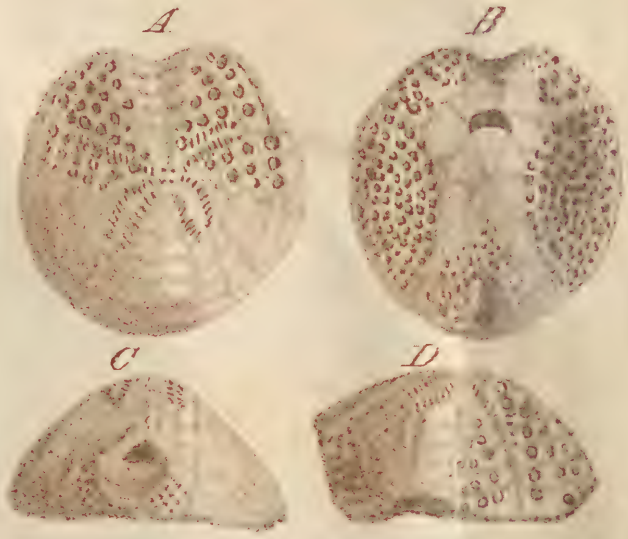
Andrews, Thomas, & Clark, Printers, Register and Observer Offices, Grenfell Street, Adelaide.

Fig. 1.



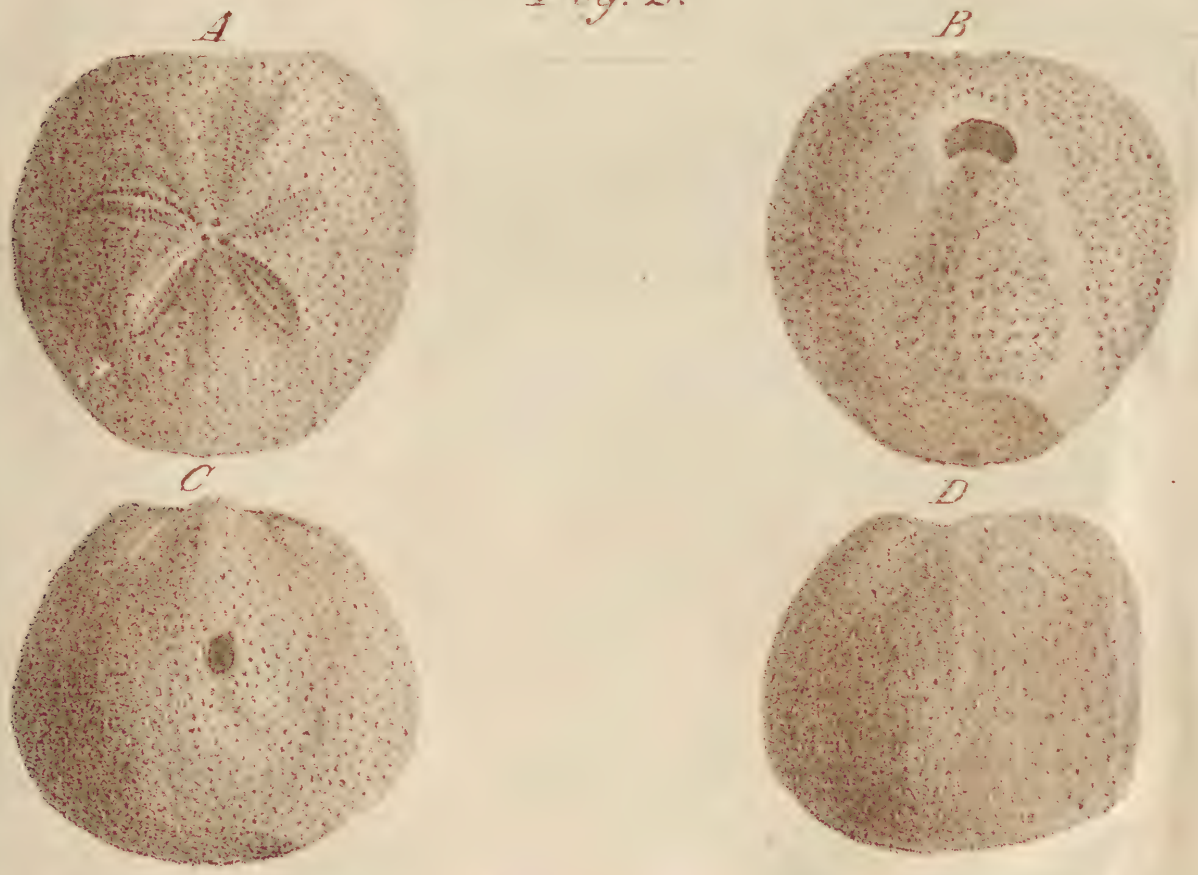
ECHINOLAMPAS GAMBIERENSIS

Fig. 3.



HEMIPATAGUS FORBESI
WOODS & DUNCAN

Fig. 2.



HEMIASTER ARCHERI

& GALBRATH. LITH.

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